

D²

37. (Amended) The integrated circuit of claim 27, wherein said thin layer of oxide has a thickness not exceeding about 500Å.

D³

44. (Amended) The integrated circuit of claim 43, further including a metal conductor in contact with said conductive layer.

REMARKS

Claims 27 - 33 and 36 - 48 remain active in this application. Claims 1 - 26, 34 and 35 have previously been canceled. Claims 28, 37 and 44 have been amended to improve form. Support for the amendments of the claims is found throughout the application, particularly in Figure 1 and the description thereof on pages 11 - 12. No new matter has been introduced into the application.

Claims 28, 37 and 44 have been rejected under 35 U.S.C. §112, second paragraph, as being indefinite; the Examiner criticizing antecedent language correspondence in these claims. This rejection is respectfully traversed as being moot in view of the amendments to these claims made above.

Specifically, in claim 28, a specific reference has been made to layer 24 of oxidized FOX on the surface of the FOX layer 22; the reference to an oxidized FOX layer in claim 27 being "on said sidewalls". In claims 37 and 44, terms not previously used in the claims have been deleted. Therefore, it is respectfully submitted that claim language accurately and unambiguously corresponds to antecedent language in the claims where such references are made and reconsideration and withdrawal of this rejection is respectfully requested.

Claims 27, 31 - 33, 36 - 41 and 43 - 46 have been rejected under 35 U.S.C. §102 as being anticipated by

Kawanoue et al., claim 28 has been rejected under 35 U.S.C. §103 as being unpatentable over Kawanoue et al. in view of Lopatin et al., claims 29 - 30 have been rejected under 35 U.S.C. §103 as being unpatentable over Kawanoue et al. in view of Lopatin et al and Yew et al. and claims 42 and 47 - 48 have been rejected under 35 U.S.C. §103 as being unpatentable over Kawanoue et al. in view of Usami. All of these grounds of rejection are respectfully traversed.

Initially, it is respectfully pointed out that in the embodiment of Figure 24 of Kawanoue et al., it is not at all clear that dielectric film 161 is a flowable oxide (FOX) material as the Examiner asserts. No reference to flowable oxide materials or any discussion of their properties is seen in Kawanoue et al. and particularly not in regard to Figure 24 or subsequent Figures. Rather, layer 161 appears to be uniformly referred to as an interlayer dielectric film which is noted to be silicon oxide at column 20, line 21.

Moreover, the first barrier layer 163 is a metal oxynitride and not an oxide layer formed of oxidized FOX, as would be consistent with the interlayer dielectric layer 161 being an ordinary silicon oxide dielectric. In fact, the basic principle of Kawanoue et al. is to provide a laminated multi-layer barrier structure including boron, carbon, oxygen and/or nitrogen compounds with metal wherein the respective layers have different compositional ratios. There appears to be no teaching (or suggestion) of protecting a flowable oxide (FOX) layer with a thin layer of oxidized FOX to protect the FOX layer from moisture, resist developers and/or metal extrusion followed by a further barrier layer (which may be a multi-layer structure) as a further extrusion barrier. Therefore, it is clear that Kawanoue et al. does not, in fact, anticipate any claim in the application since it does not teach at least "a primary protective layer...being

a thin oxidized surface of said FOX" (claim 27) or "a thin protective layer...being an oxidized surface layer of said flowable oxide insulator" (claim 38).

By the same token, Kawanoue et al. cannot form a proper basis to support a conclusion of obviousness since it does not even recognize a problem or deal with the type of materials to which the present invention is directed, much less providing a solution to that problem or leading to an expectation of success in doing so, particularly by the expedient of forming a thin layer of oxidized FOX to protect surfaces of a FOX layer which would otherwise be exposed. It should be recalled, as described in the "Background" section of the present application, that flowable oxide (FOX) is a class of materials exhibiting a very low dielectric constant which is useful in reducing capacitive coupling between closely spaced conductors but which have certain properties of susceptibility to moisture and attack by resist developers which complicate semiconductor manufacture and compromise manufacturing yield, evidently due to oxygen atoms being shared between molecules. The provision of a protective layer of oxidized FOX solves the problems of process complication and manufacturing yield without significantly compromising the average dielectric constant of the interlayer dielectric principally formed of FOX since the oxidized layer can be easily and reliably formed while being held to a very thin dimension. Therefore, the provision of a thin oxidized FOX layer supports the meritorious effects of the invention and is not taught or suggested by Kawanoue et al. for the simple reason that Kawanoue et al. provides only the well-known silicon oxide (SiO_2 - see also column 14, line 41, of Kawanoue et al.) which does not exhibit a reduced dielectric constant or susceptibility to moisture and resist developers, as an insulator and cannot be further oxidized to form a layer.

That is, if commonly used SiO_2 is used as an interlayer dielectric, there is no need for a further protective barrier but the benefits of the low dielectric constant property of FOX will not be obtained and Kawanoue et al. cannot teach or suggest a technique of protecting FOX without significant compromise of the low dielectric constant property of FOX by forming a thin layer of oxidized FOX since SiO_2 is already fully oxidized and, moreover, needs no protection other than from metal extrusion to which Kawanoue et al. is directed. The teachings and suggestions Kawanoue et al. are not supplemented at this point of deficiency by any of the secondary references with which the Examiner seeks to combine it.

Specifically, Lopatin et al. is directed to formation of a metallization barrier for a copper bonding pad and, like Kawanoue et al. the interlayer dielectric comprises alternating layers of known silicon oxide and silicon nitride. Specifically, oxide layer 108, as relied upon by the Examiner is clearly formed on nitride layer 117 (see column 3, line 35) rather than oxide layer 116 as asserted by the Examiner which, in any event, is clearly not oxidized FOX or formed on a layer of oxidized FOX (see column 3, line 22) as the Examiner asserts.

Yew et al. is cited for showing multiple Damascene layers and the Examiner does not assert or suggest that it contains any teaching relevant to flowable oxide. However, in regard to the invention, the issue of Damascene processes and dual-Damascene processes, in particular, is inseparable from the use of flowable oxide since it is the (multiple) resist development processes which compromise manufacturing yield when FOX is used as an interlayer dielectric. Therefore, Yew et al. does not supplement Kawanoue et al. and/or Lopatin et al. in regard to the use of flowable oxide or providing protection for it in the form of a layer of

oxidized FOX and cannot provide evidence of a level of skill in the art which would support a conclusion of obviousness of the claimed subject matter considered as a whole.

Usami, however, discloses use of low dielectric constant materials such as spin-on glass (SOG) but applies it after formation of conductors and provides protection, if at all, by a plasma CVD layer 17 (see column 9, lines 42 - 54), the composition of which is not indicated but, in any event, is not formed of oxidized FOX to avoid compromise of the low dielectric constant properties thereof and the film cannot be kept to a thin dimensions for that purpose by any particular treatment of the low dielectric constant material since the spin-on glass low dielectric constant material layer 5 is applied after the protective layer 17 is formed. Therefore, Usami does not teach or suggest forming a protective layer of oxidized FOX and does not supplement Kawanoue et al. in this regard.

Accordingly, it is respectfully submitted that the Examiner has not made and cannot make a *prima facie* demonstration of anticipation or obviousness of any claim in the application based on the references relied upon. The references simply do not contain the teachings or suggestions which the Examiner attributes to them and do not, singly or collectively, provide evidence of a level of ordinary skill in the art which would support a conclusion of obviousness such as the Examiner has asserted. Therefore, it is respectfully submitted that all of the stated grounds of rejection are clearly in error and untenable and reconsideration and withdrawal of the same is respectfully requested.

Since all rejections, objections and requirements contained in the outstanding official action have been fully answered and shown to be in error and/or inapplicable to the present claims, it is respectfully submitted that reconsideration is now in order under

the provisions of 37 C.F.R. §1.111(b) and such reconsideration is respectfully requested. Upon reconsideration, it is also respectfully submitted that this application is in condition for allowance and such action is therefore respectfully requested.

If an extension of time is required for this response to be considered as being timely filed, a conditional petition is hereby made for such extension of time. Please charge any deficiencies in fees and credit any overpayment of fees to Deposit Account No. 09-0458 of International Business Machines Corporation (E. Fishkill).

Respectfully submitted,



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APPENDIX

Claims 28, 37 and 44:

28. (Twice Amended) The integrated circuit semiconductor device as claimed in claim 27, further comprising,

an oxidized FOX layer on a surface of said FOX layer,

an oxide layer upon said oxidized FOX layer,
a conductor in said trough, said conductor and said oxide layer forming a planar surface, said conductor being in electrical communication with said secondary protective layer, and

a nitride layer upon said planar surface.

37. (Amended) The integrated [layer] circuit of claim 27, wherein said thin layer of [plasma-formed] oxide has a thickness not exceeding about 500Å.

44. (Amended) The integrated circuit of claim 43, further including a metal conductor in contact with said conductive [barrier] layer.